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The Power Absorbed By A 60 in. Circular Saw and Other Wood Working Machines

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THE POWER ABSORBED BY A 60 IN. CIRCULAR SAW

and

OTHER WOOD WORKING MACHINES.

A THESIS

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Submitted to the faculty

of

South Dakota Agricultural College

by

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The series of tests here described were undertaken for the purpose of determining the power absorbed by a large circular saw in cutting various kinds of timber also the power required to run various wood working machines of standard make, paper making machinery, and dynamo electric machines.

The saw mill tests were made at LaFayette, Indiana, the engine in one mill being a plain slide valve 12" x 24" Loomis and Wyman make, having run since 1881. The diagrams on plate 3 show cut off to occur at about .7 stroke. The boiler pressure was not constant owing to the variable nature of the work, running between sixty five and eighty pounds per square inch.

The engine furnishing power for the second mill tested had a cylinder 12" x 12" with a piston valve, the steam chest being beneath the cylinder and the indicator pipes being inserted in the parts just below their junction with the cylinder. Indicator cards from this engine are shown on plate 15 1/2.

In these tests where large power is absorbed, there being no suitable dynamometer at hand, the indicator

was used to secure a record of the power being developed by the engine, cards being taken when the machines were running light to secure the firction load to subtract from the indicated horse power secured when the saw was passing through the log.

Two Crosby indicators with 60 pounds springs were used to take all cards except those numbered from 80 to 100 during which time the boiler pressure was such as to permit a 40 pound spring to be used to better advantage.

The reducing motion consisting of an upright arm bearing a brumbo pulley for the indicator cord to run on and having the lower end of the arm kept in motion by a projecting piece from the crosshead or piston rod as shown in detail on plate 15 is practically the same in all tests conducted except those shown on plates 16 - 20 in which cases a pantagraph reducing motion was made use of.

On plate 1 by referring to card No. 10 the friction of engine and shafting with saw running light is found to be 12.8 horse power. By subtracting this

value from that of No. 7 the value of the power absorbed by the cut-off saw and the band saw loaded is shown to be 7.6 h.p. No. 18 shows 11.8 effective h.p. to be required to run the saw in a 4 1/2" cut in green oak while No. 30 indicates 12.8 h.p. when the saw first enters the log and increases to 27 h.p. after having passed into the log a distance of six feet.

Plate 2 is a plan and elevation showing the location of the machines and giving their sizes and speeds.

The machines of the second mill tested are driven by a 12" x 12" engine with a 54" fly wheel running when not loaded at 210 revolutions per minute. The main belt 14" wide drives a 28" pulley on the same shaft with the 60" saw. Another 28" pulley on the same shaft is belted to a shaft above carrying an 18" pulley and a 38" auxiliary saw. This saw is speeded up only when logs of a greater diameter than 28" are being cut up. In order to bring it into use a weighted belt tightener is placed in contact with the slack belt thus causing it to run with the same circumferential velocity as the large saw. The 60" saw is from the factory of W.B.

Barry, Indianapolis. It is number five gauge which corresponds to a thickness of 7/32"; it has seventy teeth of the outline shown in the first figure on plate 15 1/2.

During the time the tests were being conducted four different kinds of wood were being sawed into lumber: red oak, white ash, black walnut and sycamore.

The services of three persons were necessary to take observations simultaneously - there being two indicator cards at the same time, the actual number of revolutions of the engine for a ten second period and the time occupied in making a cut equal to the length of the log. There was also a record made of the length of log, depth of cut and kind of timber.

Owing to the slowness with which the governor acted when the saw first entered the log the indicated horse power then recorded would be too small; also cards taken immediately after the governor had changed would be too large. For this reason it was necessary for the person taking cards to observe carefully these changing conditions before taking the cards.

This accounts for the variation of results shown in the last column of plate 12 where the minimum and maximum values in foot pounds per square foot of surface sawed differ so greatly.

The engine seldom retained its normal speed throughout the cut unless the peice being sawed was of but few inches in thickness. The depth of cut in all cases was noted as was also the feed in feet per minute, this being secured for ten second periods. From the above were determined the number of square feet of lumber sawed per minute. The effective horse power reduced to foot pounds and divided by the number of square feet, obtained gives the actual foot pounds of energy required per square foot of area for the various kinds of timber experimented on.

Plates 9 and 10 show indicator cards at the factory of the LaFayette Lumber and Milling Co. where a plain slide valve Atlas engine with 12" x 20" cylinder furnishes the power. The cylinder had not been tapped for indicator pipes until all was in readiness for making the test and by a glance at the cards it will be

seen that the valve had been set quite correctly without the aid of the indicator. No. 68 shows the frictional h.p. of the engine and shafting; this subtracted from No. 65, 66 and 67 gives values shown in the last column for the effective h.p. absorbed by each machine. The largest load during the test is shown by No. 64 to be 49.2 h.p. which is below the rated power of the engine and additional machinery may be run without interfering with its running qualities.

Plates 11 and 11 1/2 contain data and calculations on the engine and machines at the factory of the Taylor Lumber Co. No. 71 shows the largest load indicated with all machines running to be 78.8 h.p. As the engine is a 150 h.p. Russell with 15" x 20" cylinder its maximum load is but one half its rated capacity. The friction of the engine and 180 feet of shafting varying in size from 2 13/16" to 4 7/16" revolving at 300 r.p.m. with 8' between bearings is 34.9 h.p. The last column of plate 11 gives the effective h.p. of the machines named in the list. The line shafting and counter shafts absorb 15.1 h.p. this being the difference be-

tween No. 79 and 72.

The LaFayette paper mill where brown paper is made from straw has its paper rolls, cutters, beaters, rotaries and pumps run by two Buckeye engines with cylinders 9" x 14" and 15 1/8" x 30". The effective h.p. of the various machines is recorded in the last column of plates 5 and 7. Card No. 31 was taken with the steam chest cover removed and the engine running at 260 r.p.m.

The Corliss engines of the LaFayette Electric Street Railway Power House were indicated with the results shown on plates 16, 17, 18, 19 and upper part of 20. No. 106, 108 and 110 shows the cut-off mechanism to be faulty in their work, permitting much more work to be done in one part of the stroke than the other.

During a three day trial of a 250 h.p. Stirling boiler furnishing steam for the 22" x 48" Hamilton Corliss engine the water consumption per h.p. per hour was found to be 29.1 lbs. The fuel consumption for the same time was 6.44 lbs. of Rosedale slack per h.p. per hour for one day and for the remaining two days when natural gas was burned the consumption was 39 cub. ft.

per h.p. per hour.

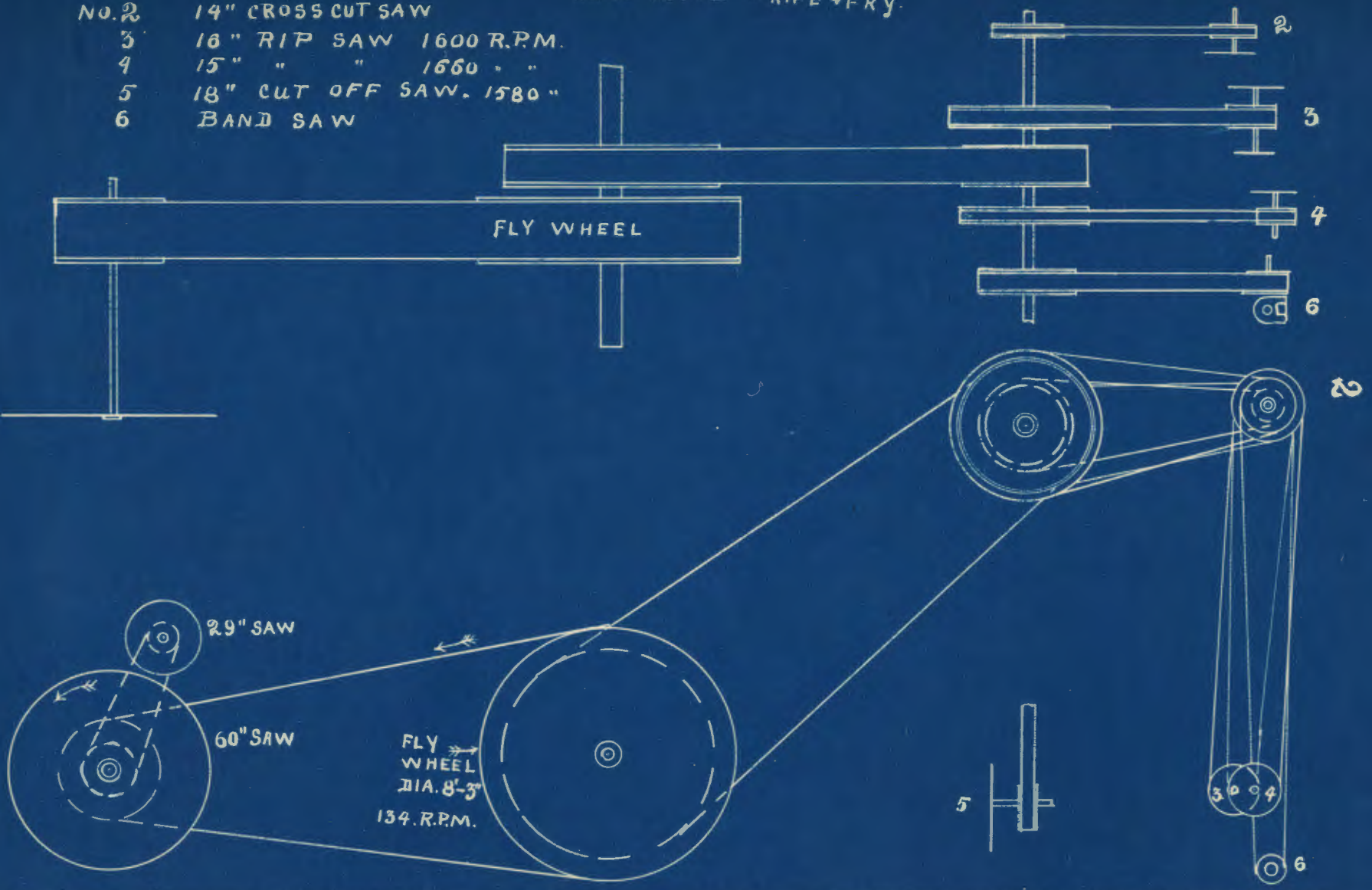
At the bottom of plate 20 are shown three sets of cards giving the average work done by a 13" x 26" Buckeye engine at the LaFayette flour mills. The average water consumption for a three days trial was 27.8 lbs. per h.p. per hour. The fuel was Rosedale slack and the amount burned per h.p. per hour averaged 6.8 pounds.

Rise-Fry SAWMILL – 12"x24" Loomis+Nyman Engine.

NO. OF CARD	R.P.M.	DEPTH OF CUT	LENGTH OF CUT	DURATION OF CUT-SEC.	M. E. P. HEAD END	M. E. P. CRANK END	M. E. P. AV.	H.P.	MACHINES RUNNING. NOTES-ETC.	EFFECTIVE H.P.
2	134	R0"	12'4"	12 Sec	27.7	28	27.8	33		
3		4½"	12'-4"	10 "	38.4	38.4	38.4			
4		4½"	12'-4"	10	16	15.2	15.6	28.1		
5		4½"	12'4"	10	16.8	16.4	16.6	29.9		
6		24"	10'2"		36.4	36	36.2		Slowed down Boiler Pressure 60 ℔	
7					11	10.9	10.9	20.4	Band saw and cutoff loaded	7.6
8		15½"	10'	13	33.6	34.6	34.1	30.1		
9									CARD TAKEN WHEN STARTING ENG	
10	134	4½	12'4"	9½	7.2	6.8	7	12.8	All machines light SEE NOTE	
11	140	4½"	12'4"	10	8	7.6	7.8	14.9	Band saw loaded	
12	136	4½"	12'4"	10	10.4	9.5	9.9	18.6	Band saw and 60" saw loaded	
13	134				6.8	5.2	6	11	All machines running light.	
14	134	18"	10'-9"	23	34	30.4	32.2	59		
15					33.2	33.5	33.4			
16	120	23"	10'-9"	12	54.7	54.8	54.7	89.9		
17					22.8	24.2				
18	141	4½"			12.8	12.8	12.8	24.6	Large saw alone loaded B.P. 80 ℔	11.8
19					11.8	11.7	11.7	22.6	Carriage reversed	9.8
20	134	22"	10'9"		32.8	31.8	32.3	59.3	Boiler Pressure 60 lbs	
21		22"	10'9"	19	40.2	40.6	40.4	74.1	B.P. 65	
22					19.6	20	19.8	36.3		
23		6½"			11.2	12	11.6	21.3		
24	143	6½"		11	17.8	18	17.9	35	B.P. 74	
25	143				6.8	6.9	6.8	13.5	Band saw loaded. All others light.	.7
26									Lost	
27	134	18"	10'	22	43.2	41.6	42.9	72		
28	134	18"	10'		40	40			Speed reduced – boiler Pressure low.	
29	134	6"	10'	10	16.8	16	16.9	30		
30	136	6"	10'		12.8	15.2	14	25.6	card taken when saw was 1" into log	12.8
	136	6"	10'		22.8	20.8	21.8	39.8	card taken when saw was 6" into log	27.

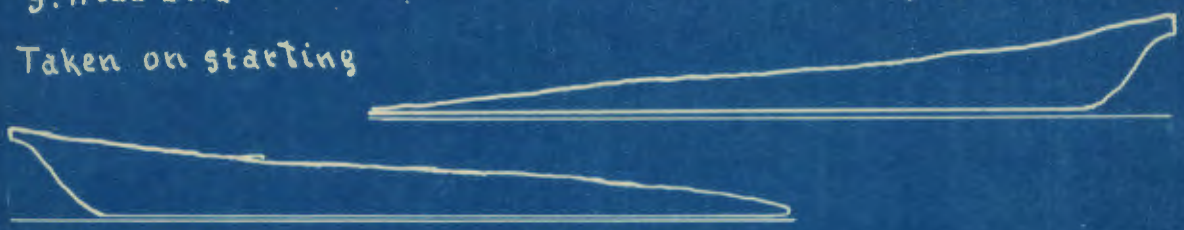
SAW MILL - RIFE & FRY.

No. 2	14" CROSS CUT SAW
3	16" RIP SAW 1600 R.P.M.
4	15" " " 1660 " "
5	18" CUT OFF SAW. 1580 "
6	BAND SAW



SAW MILL. RIFE + FRY.

9. Head End
Taken on starting

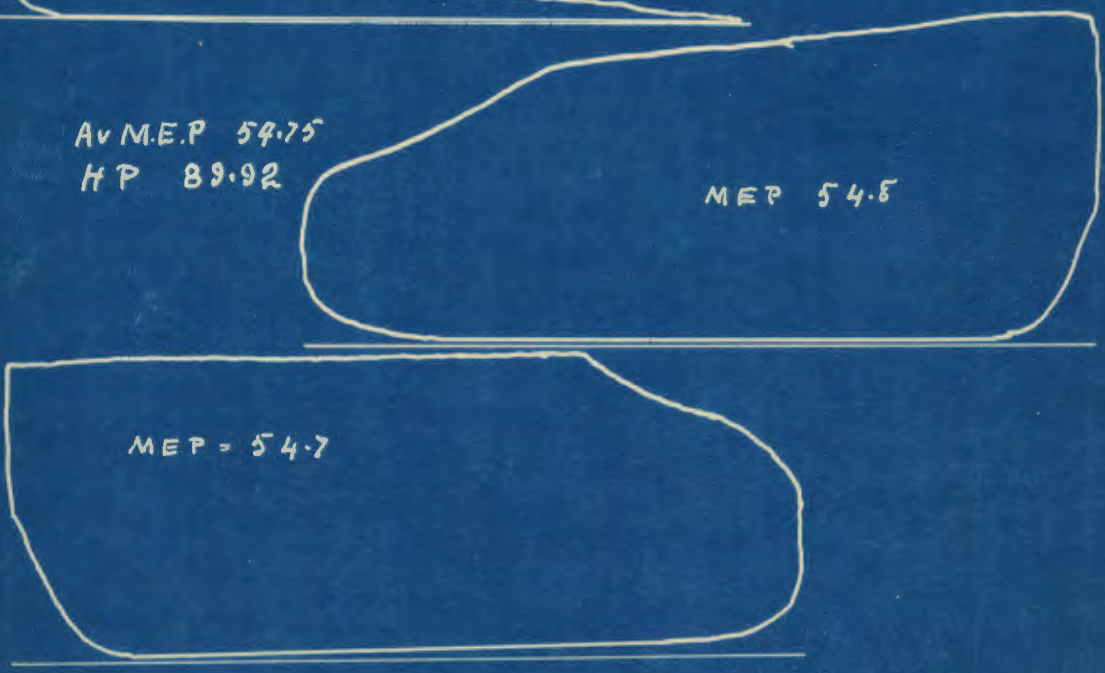


9 Crank End.

10 Av. M.E.P. 7*
H.P. 12·8

13. Av. M.E.P. 6*
H.P. 11

16 Av M.E.P 54.75
H P 89.92

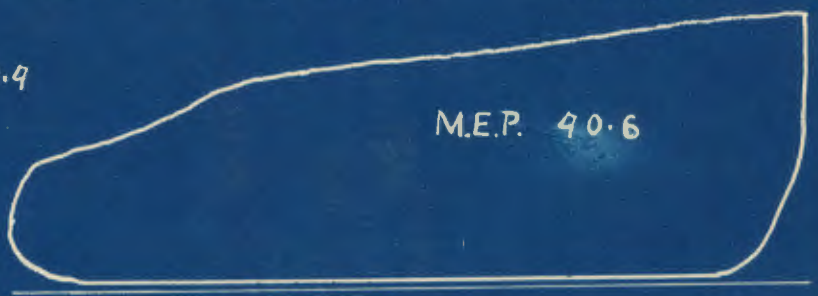


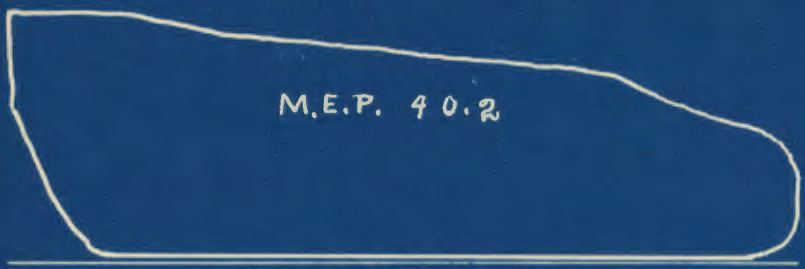
SAW MILL — RIFE & FRY

HEAD END

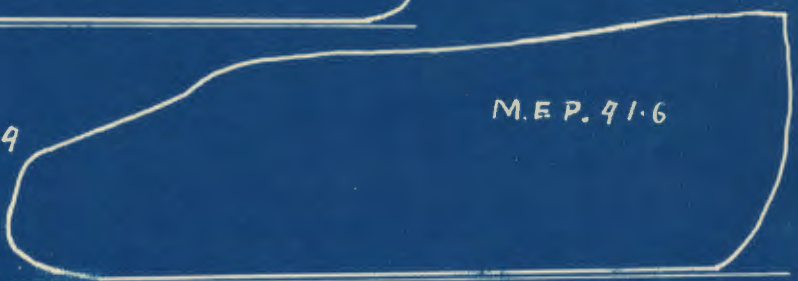
CRANK END.

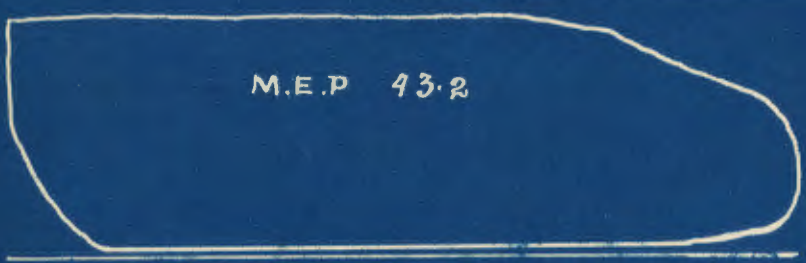
21. Av. M.E.P. 40.9
H.P. 74.1



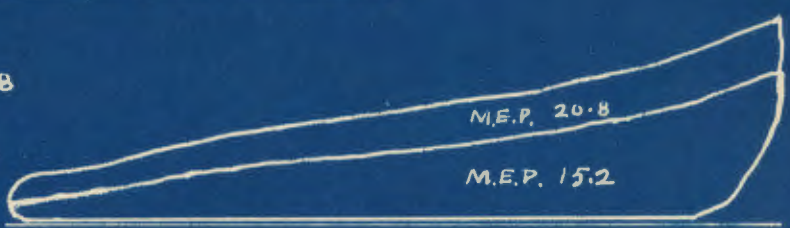


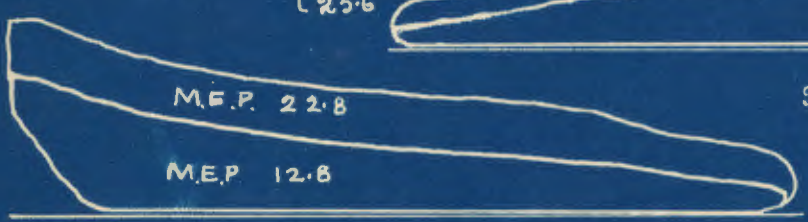
27. Av. M.E.P. 42.9
H.P. 72





30 Av. M.E.P. { 21.8 / 14.
H.P. { 39.8 / 25.6





Small card taken when saw was in the log!"
Larger one when in6'

REFERENCE NUMBER	No OF CARD	R.P.M.	M. E. P. HEAD END	M. E. P. CRANK END	M. E. P. AV.	I.H.P.	ENGINE AND SHAFT FRICTION	NAME OF MACHINES RUNNING –	OBSERVED HORSE POWER
31	1	260	8·2	9·9	9·[illegible]	5·3	AV. 5·1	ENGINE AND 20' SHAFT	
32	3	290	8·5	9	8·7	5·7		" " " "	
33	4	250	8·5	6·8	7·7	4·4		" " " "	
34	5	250	8·5	9·6	9	5·1		" " " "	
35	6	210	27·7	24·7	26·2	24		One cyl. Paper machine 48" rolls " " " " 72" rolls	
36	7	209	25·7	25·7	25·7	23·5		" " " " "	
37	8	208	25·7	23·3	24·5	22·4		" " " " "	
38	9	208	27	25	26	23·8		" " " " "	
39	10	204	27	24	25·5	23·3		" " " " "	Av. 18·3
40	11	209	27·7	21·5	24·6	22·5		Paper cutters off	
41	12	204	27·9	23·4	25·6	23·9		Paper cutters on	
42	13	204	30	23·6	26·8	24·5		Paper cutters on	
43	14	204	27	24	25·5	23·3		Paper cutters on	Av. 1·2

9" x 14" Buckeye Lafayette Paper Mill

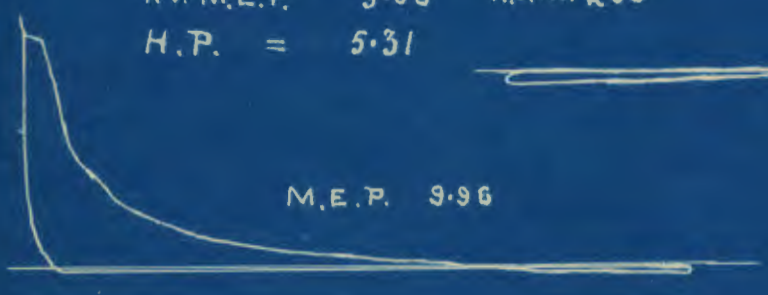
Steam chest cover removed April 16 '94.

No 31. Crank end

Friction cards

AV. M.E.P. 9·08 R.P.M. 260

H.P. = 5·31



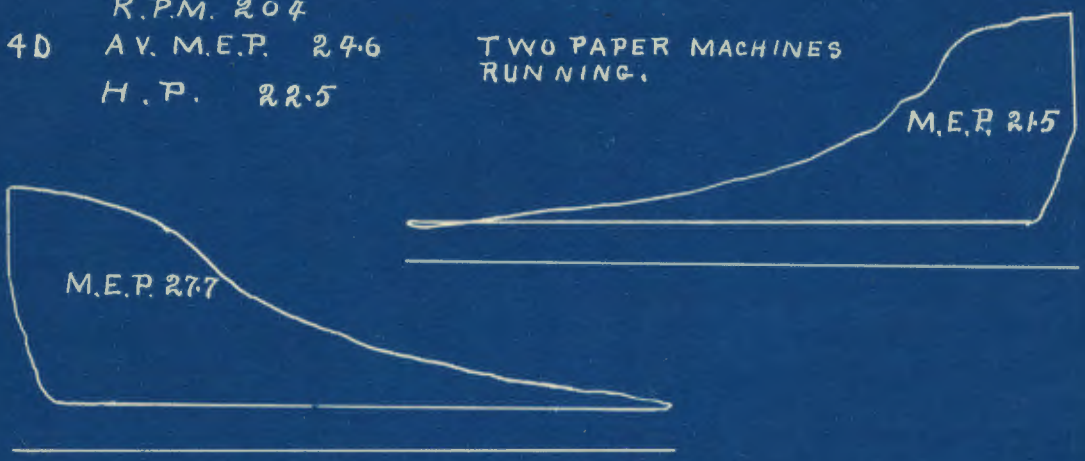
Head end

NO. 32 H. ENGINE RUNNING LIGHT. C.

R.P.M. 290
AV M.E.P. 8·7
H.P. 5·7

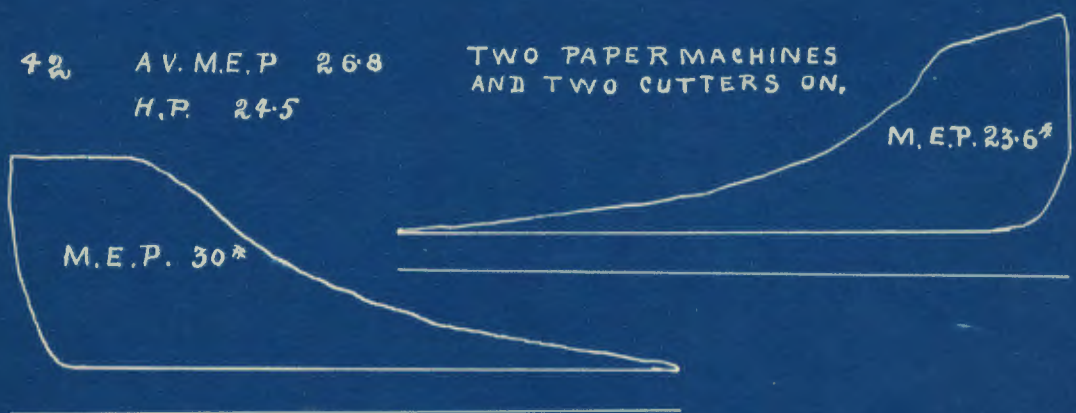
R.P.M. 204
4D AV. M.E.P. 24·6
H.P. 22·5

TWO PAPER MACHINES RUNNING.



42 AV. M.E.P 26·8
H.P. 24·5

TWO PAPER MACHINES AND TWO CUTTERS ON.



9" x 14" BUCKEYE ENGINE.

DESIGNATING NUMBER	NO. OF CARD	R.P.M.	M. E. P. HEAD END	M. E. P. CRANK END	M. E. P. A V.	I.H.P.		MACHINES RUNNING LOADED.	OBSERVED H.P.
44	1	104	40·8	34·2	37·5	105·3		2 beaters loaded. Straw cutter	
								2 " light. 1 Rotary	
45	2	104	57	51·6	54·3	152		" " "	
								" " "	
46	3	104	58·8	54	56·4	159·6		" " "	
								" " "	
47	4	104	55·8	52·8	54·3	153·6		" " "	
								" " "	
48	5	104	60	56·4	58·2	164·7		" " " SEE NOTE	
								" " "	
49	6	104	58·2	54·6	56·4	159·5		" " "	
								" " "	
50	7	104	51	45·1	48·1	136·1		Jordan light – in addition to above	
51	8	114	45	39	42	130·2		" " " "	
52	9	99	56·4	49·8	53·1	142·9		Jordan loaded " "	7 to
53	10	99	56·3	50·4	53·3	143·6		" " " "	12·9
54	11	99	55·8	50·4	53·1	150·2		" " 3 beaters 2 Rotary 1 cutter	
55	12	99	57·6	51·6	54·6	147		" " " "	
								" " "	
56	13	99	56·8	51·6	54·2	153·3		" " 4 beaters – 2 Kot's cutter.	4½ for
57	14	99	57.	51	54	152·9		" " " "	Each beater
								" " "	

BUCKEYE 15 1/8" x 30" LAFAYETTE PAPER MILL

69

Starting Engine with Full Load on.

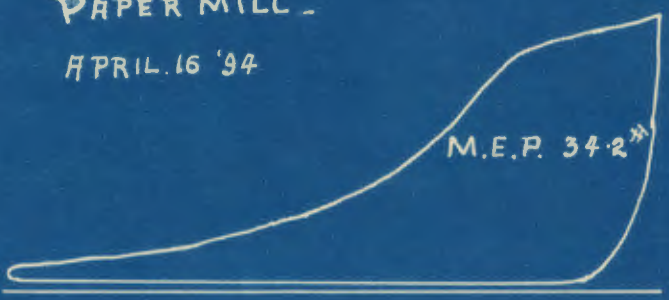
HEAD END.

BUCKEYE 15 1/8" x 30" PAPER MILL -

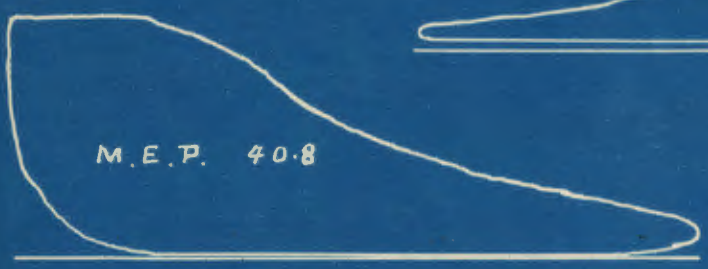
APRIL. 16 '94

C.

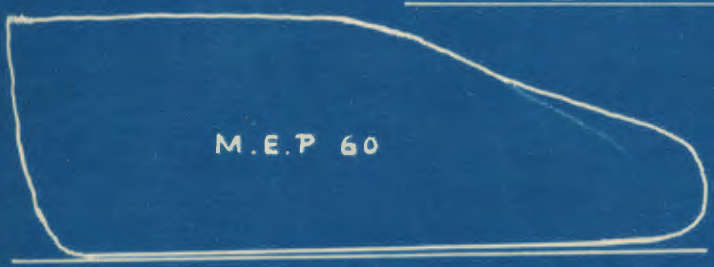
44 Av M.E.P. 37.5
H.P. 105.3



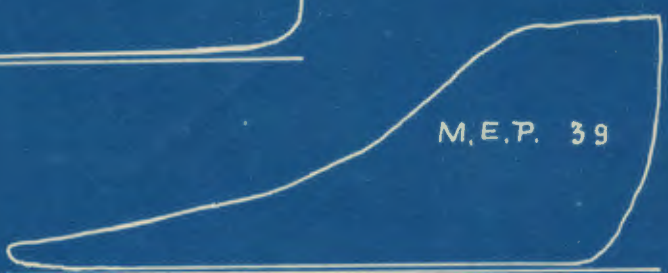
H.

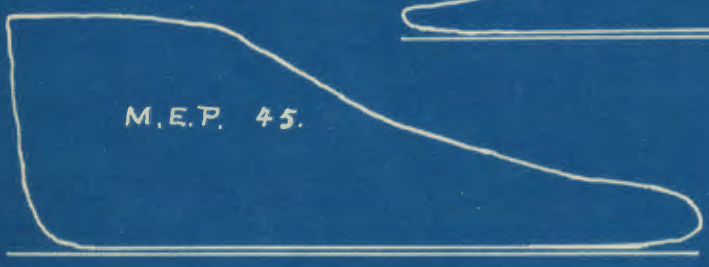


48
5. Av M.E.P. 58.2
H.P. 164.7



51 Av. M.E.P. 42
H.P. 130.2



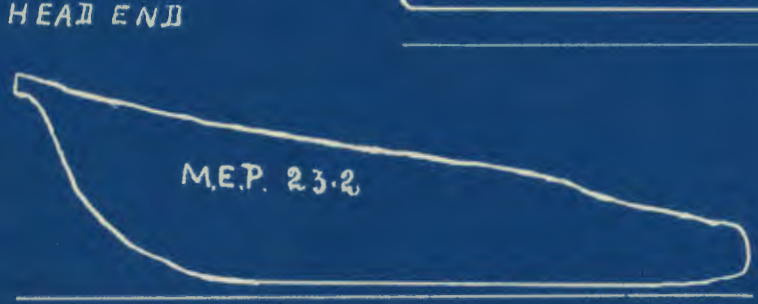


LAFAYETTE LUMBER AND MILLING CO.

REFERENCE NUMBER	No OF CARD	R.P.M.	M. E. P. HEAD END	M. E. P. CRANK END	M. E. P. AV.	I.H.P.	FRICTIONAL H.P. OF ENGINE AND SHAFTING	NAME OF MACHINE	OBSERVED H.P. LOADED
58	1	141	25.6	25.8	25.7	41.3	21.6		
59	2	148	18.3	18.9	18.6	31.4	21.6		
60	3	143	23.2	23	23.1	37.7	21.6	Planer 6"x24" BEND MCH Co CHI.	16.1
61	4	146	20	20.9	20.4	34	21.6	Planer 6x24 & 16" Rip saw	12.4
62	5	144	17.9	22.1	20	32.8	21.6	Planer - Ripsaw - Tenoner	11.2
63	6	137	19.7	20	19.8	31	21.6	Two Planers - Tenoner	9.4
64	7	142	28.8	32	30.4	49.2	21.6	Two Planers. Tenoner and Re-saw	27.6
65	8	144	18.8	19.7	19.2	31.0	21.6	Matcher	10.
66	9	145	18.5	19	18.7	31	21.6	Sander	9.4
67	10	145	16	26.8	21.4	26.8	21.6	Moulder 9". Fay.	5.1
68	11	148	12	13.6	12.8		21.6		

Atlas 12" x 20" Plain slide valve.

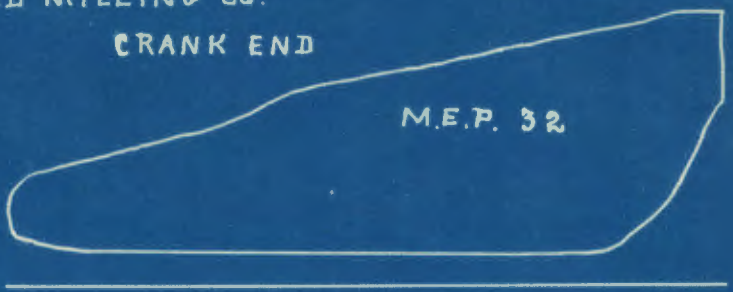
NO 60 AVERAGE M.E.P. 23.1
HORSE POWER 37.7



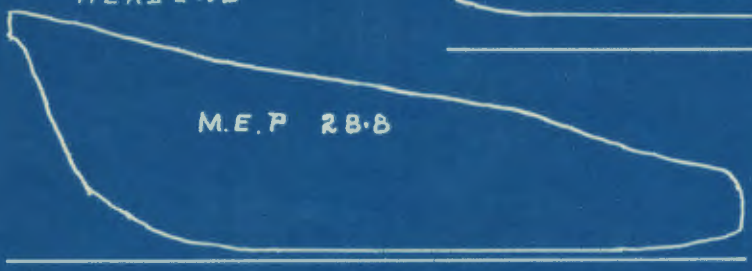
LAFAYETTE LUMBER AND MILLING CO.

NO 64 AV. M.E.P. 30.4
H.P. 49.2

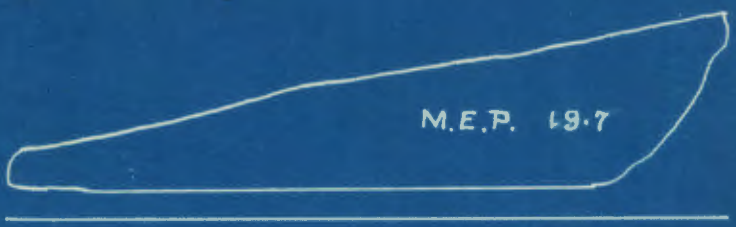
CRANK END

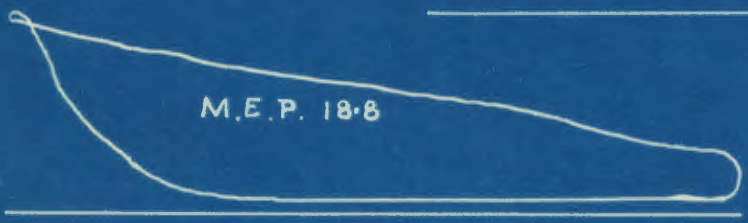


HEAD END

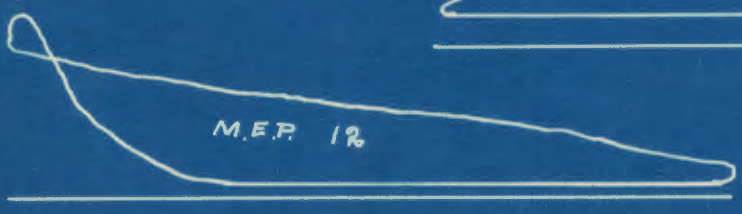


65 AV. M.E.P. 19.2
H.P. 31.6





68 AV. M.E.P. 12.8
H.P. 21.6



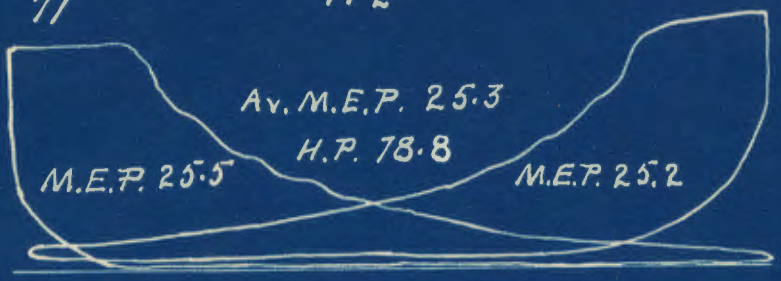
TAYLOR LUMBER CO. 15"x20" RUSSEL SEMI-CORLISS

REFERENCE NUMBER	NO OF CARD	R.P.M.	M. E. P. HEAD END	M. E. P. CRANK END	M. E. P. AV.	I.H.P.	FRICTIONAL H.P. OF ENG & SHAFT	MACHINES RUNNING — NOTES.	H.P. ABSORBED BY MACHINE
70	1	175	24.2	21	22.6	70.4	34.9	MAXIMUM LOAD — ALL MACHINES LOADED.	35.5
71	2	175	25.5	25	25.3	78.8	34.9	" " "	43.9
72	3	185	11.4	9.9	10.6	34.9	34.9	ENGINE AND SHAFTING.	
73	4	175	20.4	19.2	19.8	61.6	34.9	ALL MACHINES RUNNING LIGHT.	
74	5	185	19.5	18.3	18.7	62.2	34.9	" " "	27.3
75	6	185	13.6	12.7	13.1	43.1	34.9	MATCHER LOADED.	8.2
76	7	183	14.1	12.2	13.1	42.4	34.9	" "	7.5
77	8	183	13	11.1	12	38.8	34.9	MOULDER LOADED.	3.9
78	9	185	12.2	10.6	11.4	38.	34.9	SANDER	3.9
79	10	192	6	5.6	5.3	19.8		ENGINE & 6' JACK SHFT	
								LINE SHAFTING & COUNTERS	15.1

	KIND OF MACHINE	MAKER	GENERAL SIZES OF MACHINES	PRINCIPAL SPEEDS	OBSERVED WORK	KIND OF WOOD	H.P. ABSORBED BY MACHINE
78	SANDER	BERLIN MCH WORKS DETROIT	Length of Roll 48" Dia 11.4" 3 — 16" Belts	Rolls 1000 R.P.M.	14 linear ft. per. min. 14" Board	Bass-wood	3.9
77	MOULDER	EGAN CO. Cincinnati	8" 4 sided Driving shaft 1090 R.P.M.	TOP CUTTER 5" DIA 4000 R.P.M.	FEED 25 ft. per. min. 450 cub in. of chips per min.	white Pine.	3.96
75 76	MATCHER	GLEN COVE MCH. CO. BROOKLYN.	6" x 14" 4" belt. side cutters 4½ " Top " DIA. TOP cutter 5" " Side " " 6"	cutters 3600 R.P.M. Shaft 700	550 cub. in. chips per min.	Hemlock (wet.)	8.2 7.5

71

11½



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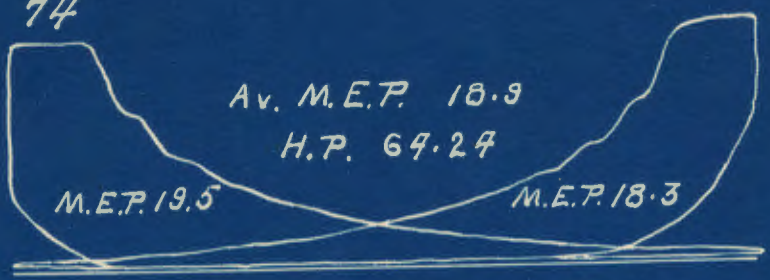

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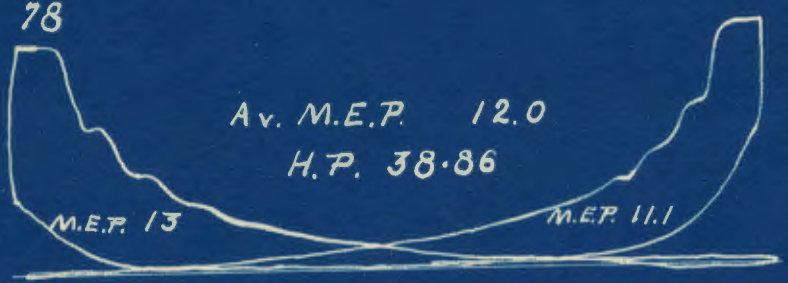

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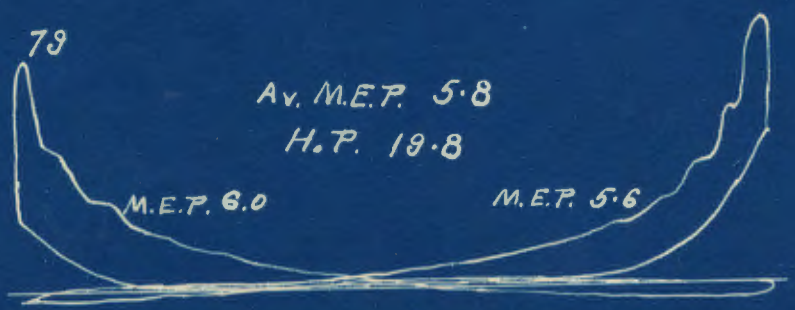
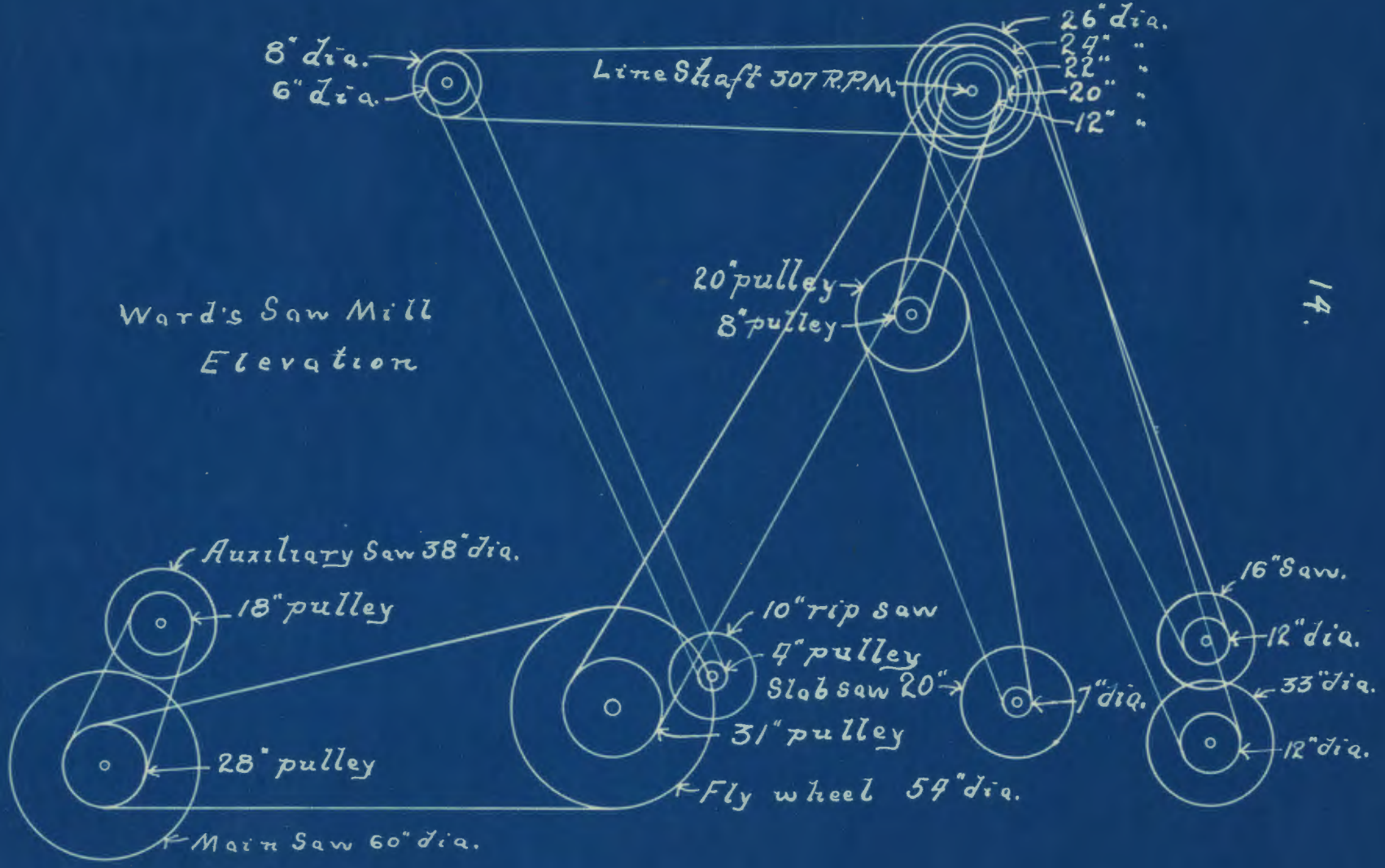


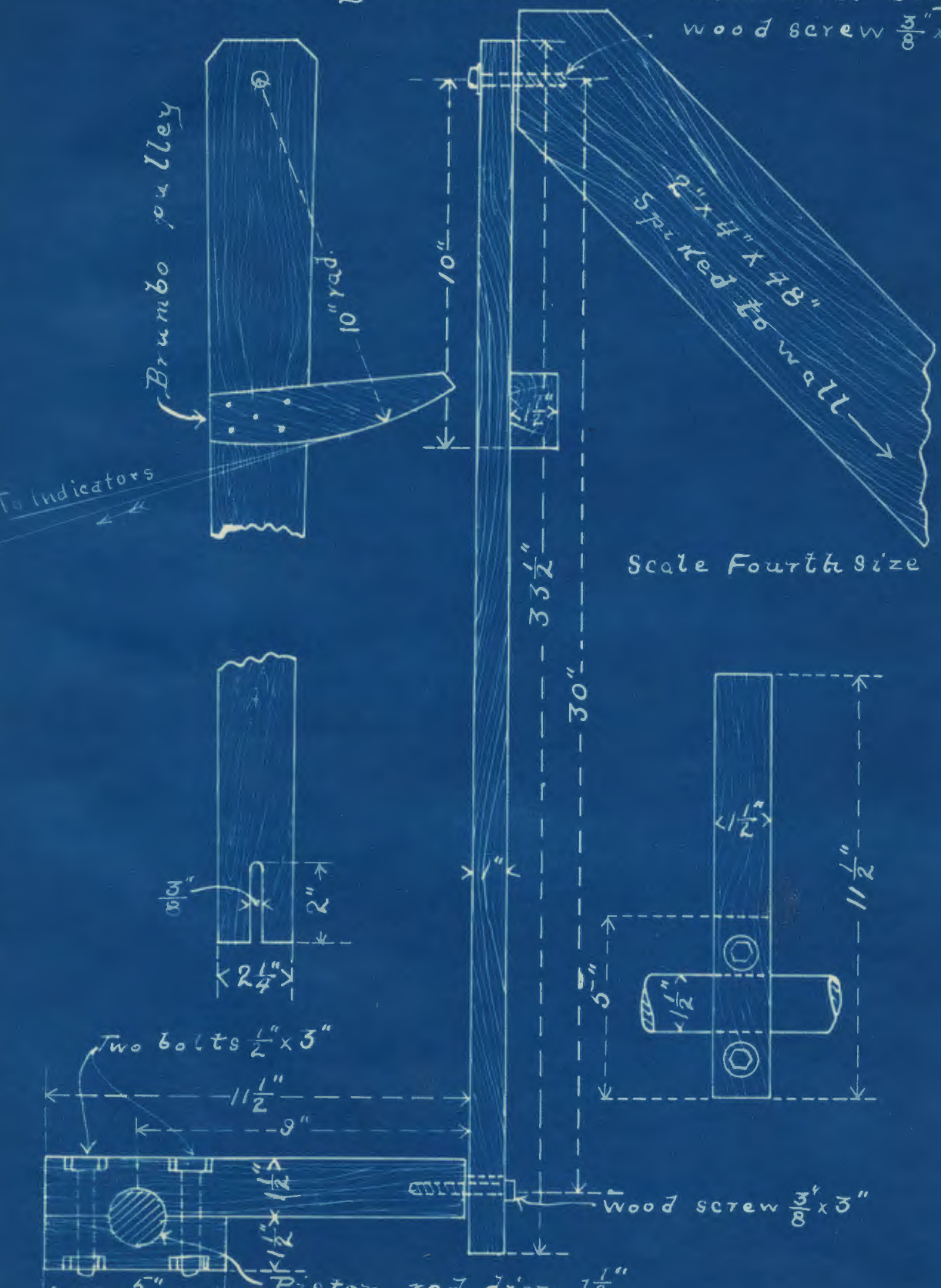
SAW MILL - WARD.

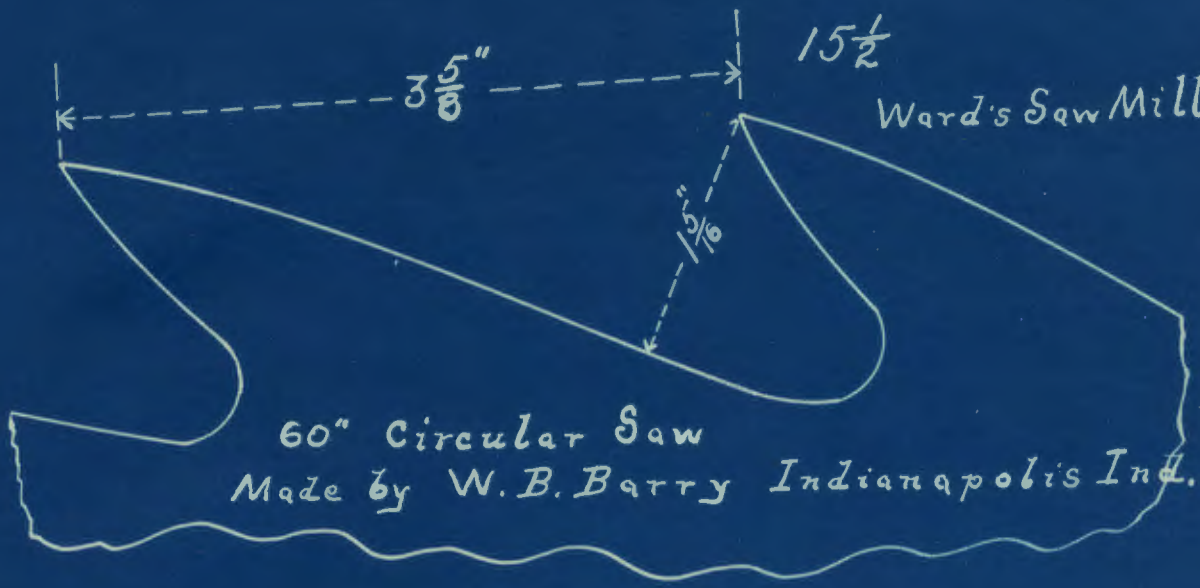
REFERENCE NUMBER.	NO. OF CARD	R.P.M.	M. E. P. HEAD END	M. E. P. CRANK END	M. E. P. AV.	I.H.P.	NET H.P.	KIND OF TIMBER	FEED. FEET PER MIN.	DEPTH OF CUT — INCHES	SURFACE CUT PER MIN SQ. FEET	FOOT POUNDS OF WORK DONE
80	1	168	24.8	28.	26.4	30.3	16.6	RED OAK	70.8	6	354	15474
81	2	168	40.4	45.2	42.8	49.3	35.6	RED OAK		12		
82	3	168	21.6	24.6	23.1	26.5	12.8	RED OAK	70.8	6	354	
83	4	168	36.8	42	39.4	45.4	31.7	RED OAK	70.8	6	35.4	29550
84	5	144						RED OAK	55.7	6	27.8	
85	6	195	12.6	14.6	13.6	18.2	4.5	WHITE ASH		3		
86	7	174	32.4	39.4	35.9	42.8	29	" "				
87	8	168	35.5	38.3	36.9	42.4	28.7	" "	554	12	554	17094
88	9	162	46.5	51.2	49	54.4	40.6	" "	45	15	562	23640
89	10	162	47.6	52.8	50.2	55.7	42	" "		18		
90	11	168	26.4	29.2	27.8	32	18.3	" "		8.5		
91	12	210	9.4	11.8	10.6	15.3	1.55	" "				
92	13	216	7.2	9.2	8.2	12.1		" "				
93	14	210	7.2	10	8.6	12.4		" "				
94	15	180	29.6	32.6	31.1	38.4	24.6	BLACK WALNUT	554	9	415	19561
95	16	144	36	40	38	37.5	23.7	WHITE ASH		22		
96	17	192	36.4	40	38.2	50.2	36.5	"	43	15	54	22305
97	18	192	28	34.4	29.2	38.4	24.7	"				
98	19	168	48	54	51	58.7	45	"				
99	20	144	47.2	51.7	49.4	48.7	35	RED OAK	33.3	21	62.4	18670
100	21	180	31.8	32.6	32.2	39.7	26	SYCAMORE	52.	24		
101	22	192	36.	39.6	37.8	49.7	36	"	554	23	106	11207
102	23	186	36.6	40.8	38.7	49.3	35.6	"	537	23	103	11700
103	24	186	38.4	43.8	41.1	52.3	38.6	"	537			
104	25	192	33	36	34.5	45.4	31.7	"	554	12	554	18465
105	26	210	8.5	10.8	9.6	13.8	1.7	"				

Ward's Saw Mill.
Plan.


8" dia.
6" dia.
Line Shaft 307 R.P.M.
26" dia.
24" "
22" "
20" "
12" "
20" pulley
8" pulley
Ward's Saw Mill
Elevation
Auxiliary Saw 38" dia.
18" pulley
28" pulley
Main Saw 60" dia.
10" rip saw
4" pulley
Slab saw 20"
31" pulley
Fly wheel 54" dia.
7" dia.
16" Saw.
12" dia.
33" dia.
12" dia.

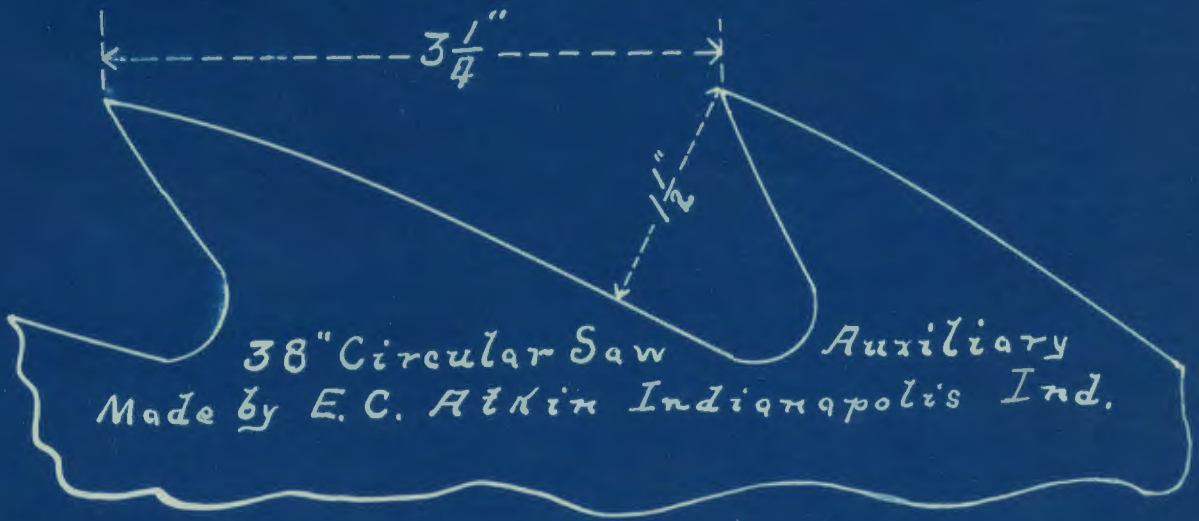
Reducing motion Ward saw mill Engine





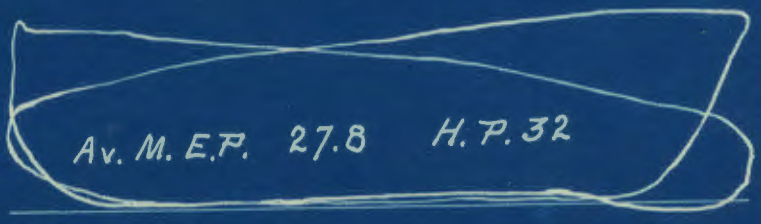
Ward's Saw Mill

60" Circular Saw
Made by W. B. Barry Indianapolis Ind.



38" Circular Saw Auxiliary
Made by E. C. Atkin Indianapolis Ind.

Av. M. E. P. 8.2 H.P. 12.13



Engine 12"x12" Piston valve

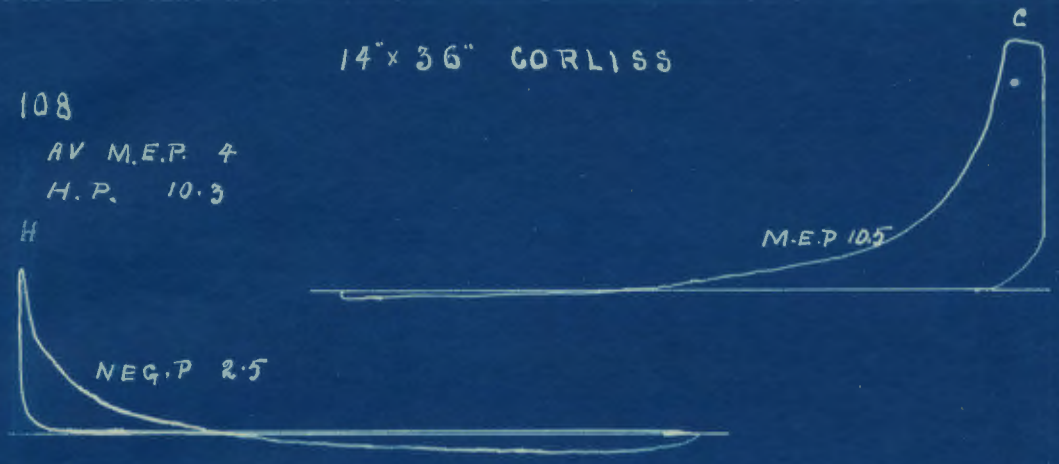
14"x36" AND 22"x48" HAMILTON-CORLISS ENGINES.

REFERENCE NUMBER	NO OF CARD	R.P.M.	M. E. P. HEAD END	M. E. P. CRANK END	M. E. P. AV.	HORSE POWER	NAME OF MACHINE	General sizes - notes.	H.P. Absorbed by Generator.
106	1	88	0	666	3.3	5.4	ENGINE AND JACK SHAFT		
107	2	88	4.1	8.5	6.3	15.5	" " AV. 10.4		
108	3	92	-2.5	10.5	4	10.3	2 Generators Light	2-60 Kilowatt Generators 860 R.P.M.	
109	4	92	7.3	11.3	9.3	24.	" " AV 17.1	820 R.P.M.	6.6
110	5	87	29.3	34.6	32.	77.9	2 Generators Loaded		
111	6	87	24.3	26.4	25.3	60.9	" " AV 69.4 "		59.
112									
113		22"	x	48"	Corliss				
114	7	72	4.46	2.4	3.4	22.6	ENG. + SHAFT		
115	8	72	2.9	5.7	3.9	25.8	" " AV 24.2		
116	9	72	5.5	7.9	6.7	49.3	2 Generators Running Light		
117	10	72	6.2	6.1	6.15	40.7	2 Generators AV 42.5 " "	2-100 K.W. Generators & Small.	18.3
118	11	72	7	6.1	6.5	43.6	" " AV 44.8	Loaded - no cars out	
119	12	72	7.8	6.1	6.9	46	" "		20.6

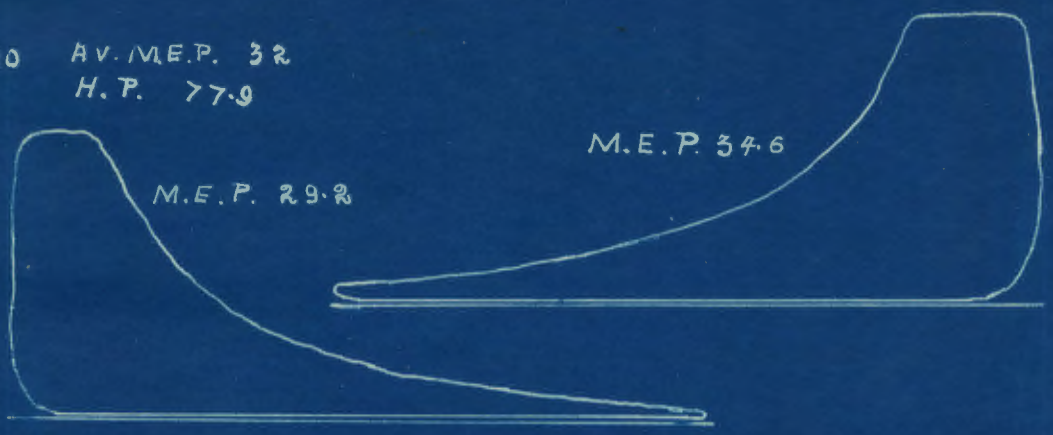
LAFAYETTE STREET RAILWAY POWER STATION.

14" x 36" CORLISS

108
AV M.E.P. 4
H.P. 10.3



110 AV. M.E.P. 32
H.P. 77.9

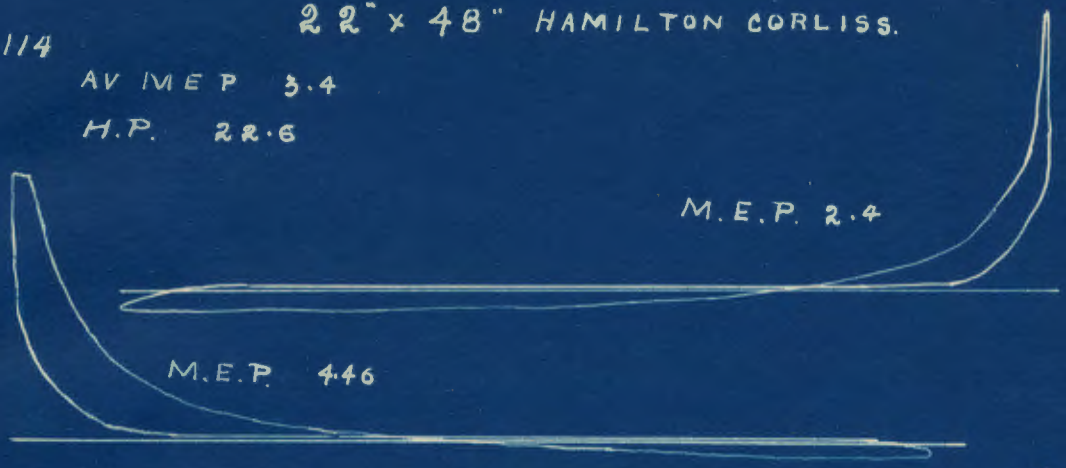


22" x 48" HAMILTON CORLISS.

114

AV M E P 3.4

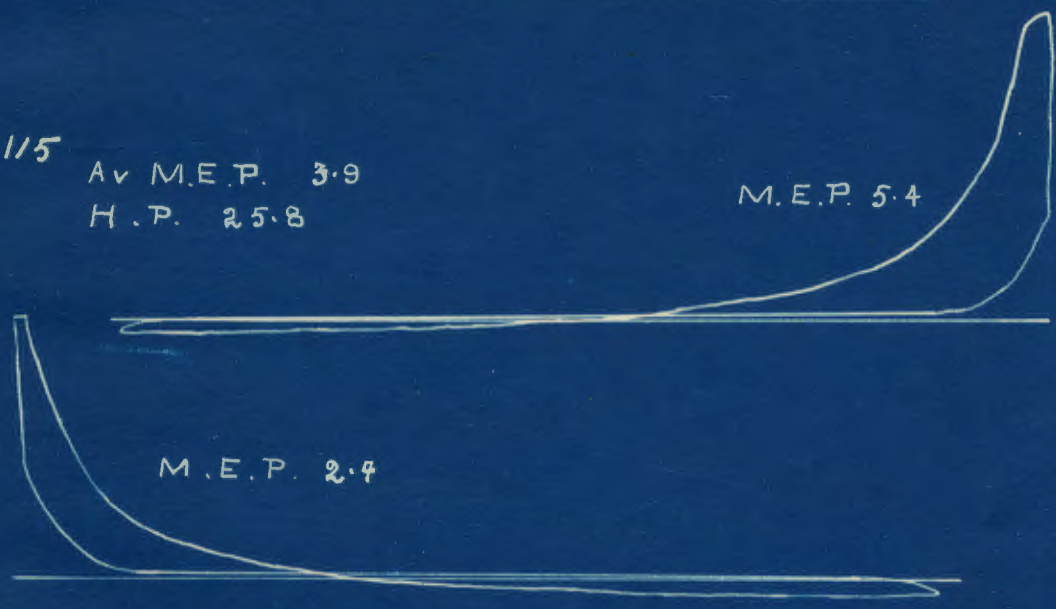
H.P. 22.6



115

Av M.E.P. 3.9

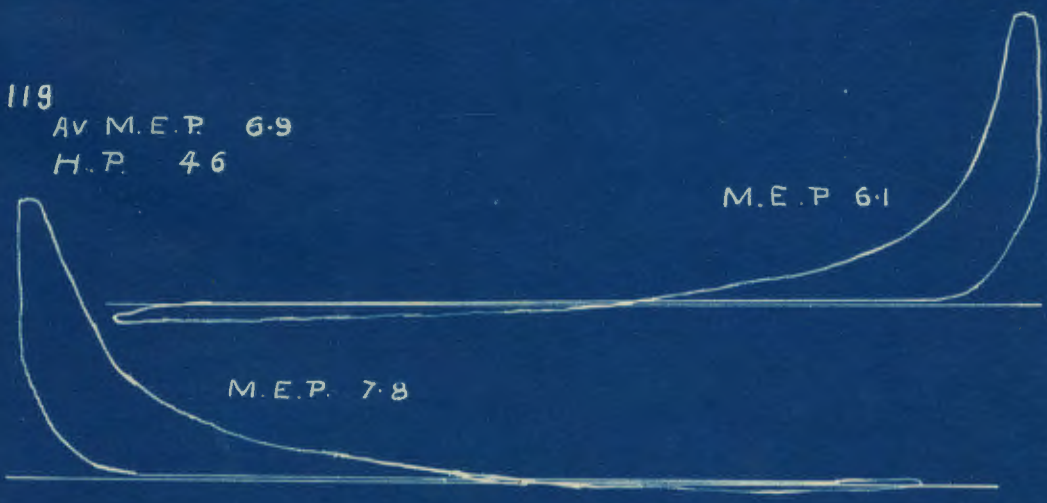
H.P. 25.8



119

Av M.E.P. 6.9

H.P. 46



19

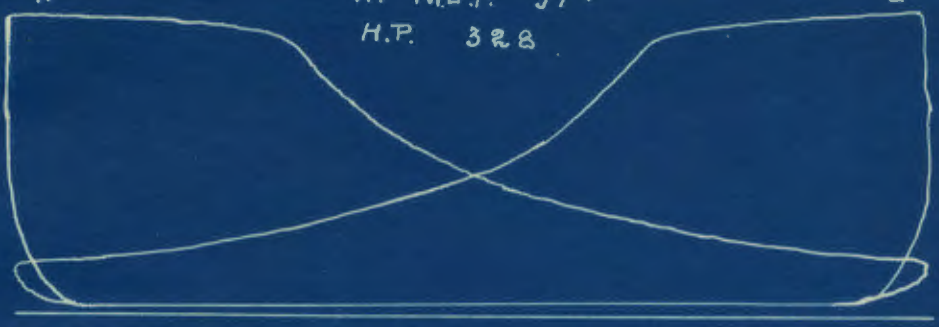
120 22" x 48" HAMILTON CORLISS

AV M.E.P. 51 #

H.P. 328

H

C



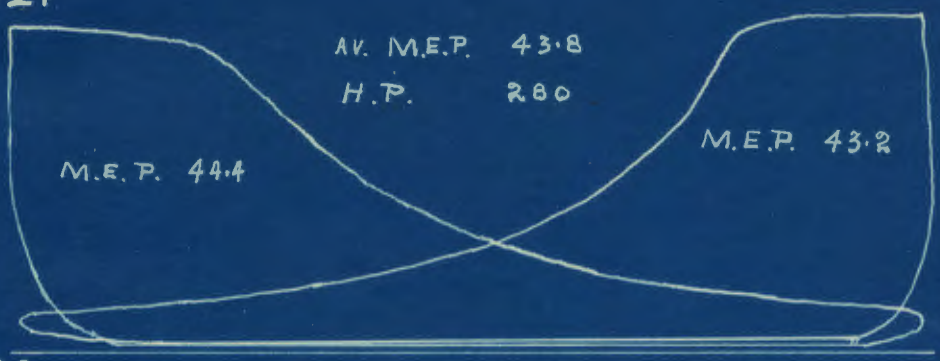
121

AV. M.E.P. 43.8

H.P. 280

M.E.P. 44.4

M.E.P. 43.2



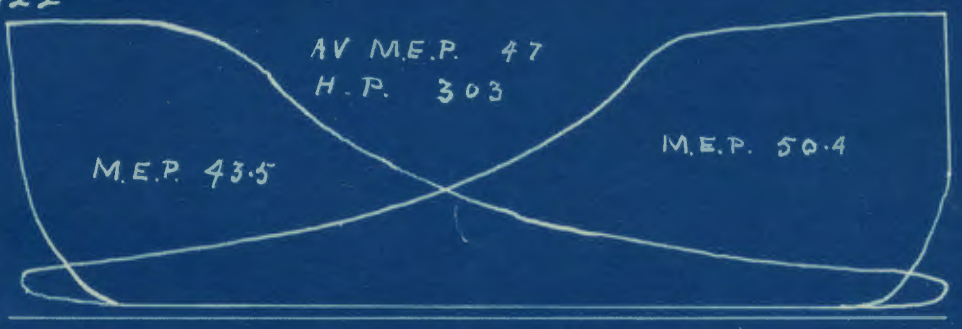
122

AV M.E.P. 47

H.P. 303

M.E.P. 43.5

M.E.P. 50.4



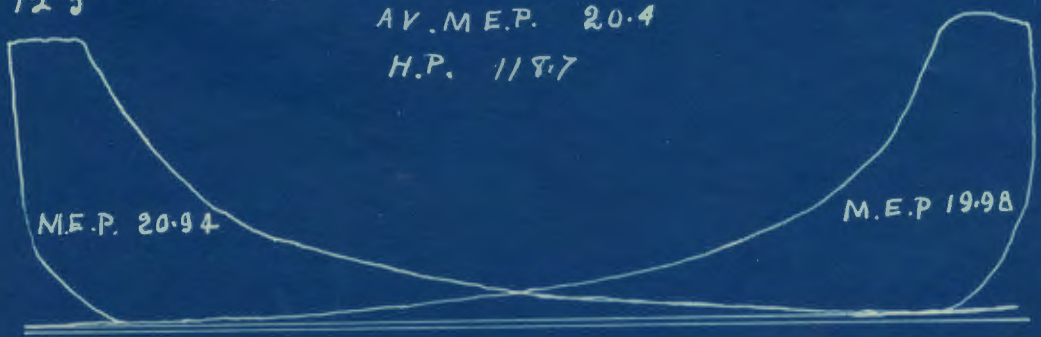
123 AVERAGE CARD FOR 3 DAYS TEST

AV. M.E.P. 20.4

H.P. 1187

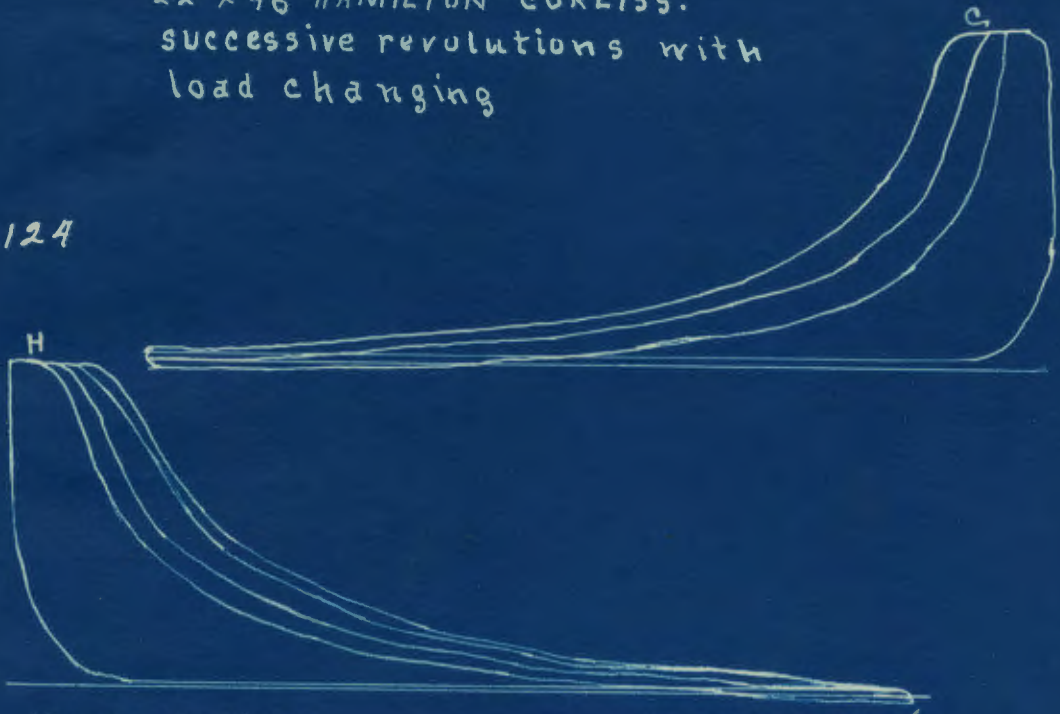
M.E.P. 20.94

M.E.P 19.98



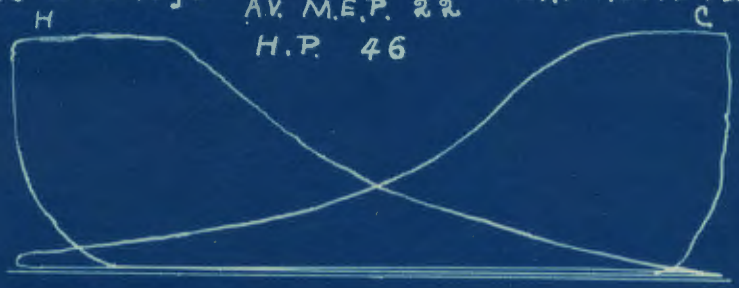
22 × 48 HAMILTON CORLISS.
successive revolutions with
load changing

124



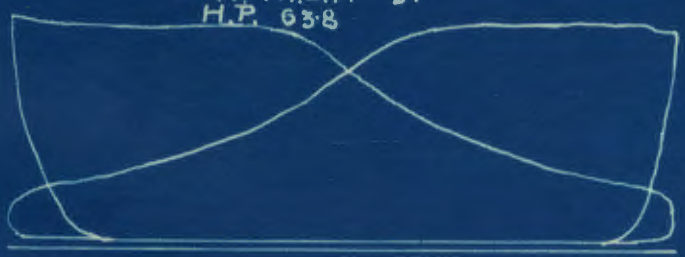
13 × 26 Buckeye A.V. M.E.P. 22 LAFAYETTE FLOUR MILL.
H.P. 46

125



A.V. M.E.P. 31
H.P. 63.8

126



A.V. M.E.P. 32.8
H.P. 69.6

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